Smoking Behavior Literature Review

Publication Title	Authors	Journal Citation	Population Sample Size	Duration of Study	Study Objectives	Results and Conclusions	Methods of Measurement	Statistical Analysis	Mention of Confounders
[illegible]	Ashton, H., Watson, D.W., Marsh, R., and Sadlers, J.	British Medical Journal (1970, volume 3, p. 679-681)	36 smokers (15 females and 21 males, 19-35 years old)	One time	To determine the effect of puffing on nicotine intake and compensation	* Smokers of cigarettes with high-retention filters took more frequent puffs and obtained nearly the same amount of nicotine as smokers of cigarettes with low-retention filters, both while performing the tasks and during the resting period * Smokers of both types of cigarettes took significantly more puffs and obtained more nicotine per unit time during the resting period than during the tasks * It is possible that smokers automatically adjust the nicotine dose obtained from a cigarette to some "optimum" level which may vary with different activities	* Each puff at a cigarette was recorded by an observer and time of start and finish of each cigarette was noted * Cigarette stubs were analyzed for nicotine content (nicotine presented to smoker) * Respiratory rate was measured by impedance pneumography by means of two Devices skin electrodes and recorded on a Beckman Dynograph recorder * Subjects' reaction times to the panel light signals during the task, and physiological functions including heart rate, blood pressure, and calf blood flow were also recorded	t-tests	
[illegible]	Battig, K., Buzzi, R., and Nil, R.	Psychopharmacology (1982, volume 76, p. 139-148)	67 male and 43 female smokers (16-78 years old)	90 minute session	To compare puffing behavior quantitatively across smokers of different types of cigarettes and to estimate inhalation by measure both CO yield of the cigarettes and CO levels in expiratory tidal air	* Puff shape, puff volume, and puff frequency accounted for about 50% of variation obtained with the different puffing variables * Expiratory tidal CO levels increased with the number of cigarettes smoked before the tests and with the intensity of the smoking habit, but pre- to postsmoking change in tidal CO differences were similar for smokers of all types of cigarettes * Volume compensation for differences of smoke yield fo the cigarettes was generally morep ronounced in women than in men, and, additionally, it was more pronounced for cigarettes with standard smoke nicotine yield below 0.9 mg for both sexes * Only for women, partial correlation procedures suggested that nicotine might be more important in determining puffing behavior than CO and condensate yield, but there were also no women smoking the strongest cigarettes * Personality ratings, pulmonary functions, and cardiovascular functions were not, or only inconsistently, correlated with puffing behavior or type of cigarette	* A cigarette holder-puffing flow meter was used to determine puffing flow and pressure * Module developed to analyze puff volume, puff duration, peak pressure, latency to peak pressure, and interval from the preceding puff * Expiratory tidal air collected and analyzed with Ambient CO Monitoring System * Module Hopsital-Calculair used to monitor forced vital capacity, forced 1-s expiratory volume, and peak flow * Module Elag Be-297-S was used to measure pulse rate and blood pressure * Questionnaires on drug usage, demographics, and personality	Correlational analysis; factor analysis; discriminant analysis; and partial correlation procedures	Intersex differences in puffing behavior

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[redacted]	Benowitz, N.L., et al.	New England Journal of Medicine (1983, volume 309, p. 139-142)	272 (122 males, 150 females, average age of 37, all about to begin a smoking treatment program)	One time	To determine whether or not the measured yield of a cigarette corresponds to actual consumption of nicotine (As measured by blood cotinine levels)	* Nicotine concentration in tobacco inversely correlated with the concentrations measured by smoking machines * Blood cotinine concentrations correlated with the number of cigarettes smoked per day but not with nicotine yield * Because of long half-life, cotinine concentrations vary relatively throughout a day of smokign and thus are a consistent measure of nicotine exposure * Blood cotinine concentration si not a perfect marker of nciotine consumption, because of individual variability in both the conversion of nicotine to cotinine and the elimination rate of cotinine itself * The main determinants of whether a cigarette has a low or a high yield in machine testing are the charactertistics of its ventilation and burning * These variables are under the control fo the cigarette smoker * Blood cotinine concentration is nto a perfect marker of nicotine consumption, because of individual variability in both the conversion fo nicotine to cotinine and the elimination rate of cotinine itself	* Nicotine concentrations measured by high performance liquid chromatography * Blood samples were taken and measured for nicotine and cotinine intake with gas chromatography	Univariate linear regression and hierarchical multiple linear regression	Smokers who participated in this study were seeking treatment; blood cotinine concentration is not a perfect marker of nicotine consumption because of individual variability in both the conversion of nicotine to cotinine and the elimination rate of cotinine itself

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[redacted]	Bridges, R.B., et al.	Pharmacology, Biochemistry, and Behavior (1990, volume 37, p. 29-39)	170 male smokers (mean age of 37.8)	One time	To determine if differences in puffing topography were associated with cigarette yield and to determine the relationships of puffing topography with population or smoking history characteristics and smoke exposure or absorption	* Of the puffing topography variables, interpuff interval appeared to be the primary determinnat of blood concentrations of smoke constitutents * Smokers of low nicotine yield cigarettes partially compesnated for these lower yeilds by increasign the ttoal volume puffed per cigarette * Observed fifferences in puffing topography associated with increased daily cigarette consumption and cumulative smokign history were consistent with a higher smoke exposure per cigarette * Although both alcohol and coffee consumption are associated with present and cumulative smoking history, coffee consumption is uniquely associated with differences in puffing topography consistent with a higher smoke exposure per cigarette * Neither coffee nor alcohol consumption histories added significantly to the prediction of blood concentrations of smoke constituents over that obtained by smoking history and puffing topography	* Questionnaire on health, smoking and drug usage, and alcohol and coffee consumption * Pressure transducer attached to cigarette holder used to calculate the number of puffs per cigarette, interpuff interval, duration and volume of each puff, mean volume and duration per puff, and total puff volume and duration per cigarette * Serum thiocynate and blood carboxyhemoglobin were determined spectrophotometrically, while plasma nicotine and cotinine concentrations were determined by radioimmunoassay	ANOVA, univariate and multivariate analyses	Cigarette holder pneumotachograph, smoking setting, and time since last cigarette can influence puffing behavior; interindividual variability
[redacted]	Bucchalter, A.R., and Eissenberg, T.	Nicotine and Tobacco Research (2000, volume 2, p. 39-43)	10 light or ultra-light cigarette smokers (mean age of 23.2 years, 7 female and 3 male)	Two 2-hour sessions	To determine the effects of Accord on subjective and physiological measures and smoking behavior	* When using the Accord, the magnitude of smoking-induced craving reductions and the physiological effects of smoking were less, and puff volume and frequency were greater than when subjects smoked their own brand of cigarettes * The expired air CO increases after smoking own brand cigarettes did not occur after using the Accord * The Accord may deliver nicotine less efficiently that normally marketed cigarettes * compensation may occur * Heart rate increase less with Accord * Skin temperature decreased less with Accord * Interpuff intervals were shorted with Accord * Puff volume and duration were greater with Accord	* Breath CO sample was taken * Fagerstrom nicotine tolerance questionnaire given * VAS subject-rated measures on withdrawal symptoms * Questionnaire of Smoking Urges (intention to smoke and anticipation of relief from withdrawal) * Heart rate, skin temperature, and blood pressure measured with Noninvasive Patient and monitor model 507E * Expired CO levels were taken before and after each cigarette with Breath CO monitor * Topography data was computerized and a pressure transducer used to measure puff volume, puff duration, puff number, and interpuff interval	ANOVA; Hunh-Feldt corrections; Tukey's significantly different test	Subjects were only mildly dependent; received only acute exposure to the novel system; were not blind to smoking condition; no placebo condition; small sample size

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[redacted]	Bucchalter, A.R., Schrinel, L., and Eissenberg, T.	Nicotine and Tobacco Research (2001, volume 3, p. 111-118)	16 female and 16 male smokers of light or ultra-light cigarettes (mean age of 25.9 years)	Four 2.5 hour sessions	To determine the effect of the Accord cigarette on withdrawal of suppression and biomarkers of exposure	* Withdrawal suppression, CO intake, and tachycardia produced by Accord are all less than that produced by normally marketed cigarette brands, even controlling for the system's 8-puff limitation and for brand preference * Incomplete withdrawal suppression may increase smoking frequency, thus potentially offsetting any decreased risks associated with Accord use * Greater reductions in subjective craving and QSU scores were observed when subjects took their puffs from normally market brands as opposed to the Accord	* CO breath screening at start * Nicotine dependency measured by Fagerstrom nicotine tolerance questionnaire * Quit attempts history taken * VAS scale to measure tobacco withdrawal symptoms * Questionnaire of Smoking Urges * Heart rate and skin temperature monitored continuously using the Noninvasive Patient Monitor 507E * CO measured before and after each cigarette using breath CO monitor * Topography data was computerized using pressure transducer to get puff volume, duration, and interpuff interval	Mixed ANOVAs; Huynh--Feld corrections; Tukey's significantly different test	Some subjects had sessions at different times of the day; the use of only smokers of light and ultra-light cigarettes limited; subjects were not familiar with Accord system; no control for menstrual cycle phase
[redacted]	Burns, D.M.	US Consumer Product Safety Commission contract			To review and give recommendations for analyses of low-ignition cigarettes and toxicity and carcinogenicity	* A number of changes contemplated to reduce the potential of cigarettes (e.g., higher porosity paper, less densely packed tobacco, different tobacco blends) may alter the chemical composition of the smoke, potentially changing its toxicity and carcinogenicity, as well as topography * Any new agent added to the cigarette, and its pryolysis products, have the potential to increase the toxicity of the smoke or to add qualitatively different toxicities * smokers who smoke lower yield cigarettes compensate by changing puff volume and frequency * The short half-life CO in the blood means that the levels are heavily influenced by the intensity of smoking in the hours immediately prior to measurement →	* Nicotine and cotinine levels are very specific measures of exposure to tobacco smoke, and cotinine levels are the most widely accepted measure of smoking status and the amount of smoke retained is imprecise * recommends a brand-to-brand comparison of risk using machine testing, bioassay testing, a listing of additives used in the cigarette brand, and, finally, human testing		

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	Diding, N.	International Journal of clinical Pharmacology, Therapy, and Toxicology (1987, volume 25, number 3, p. 143-147)			To review recent studies on plasma concentrations and the application of pharmokinetic parameters in human smoking, self-regulation and compensation when switching between different brands, and the relationship between in vitro machine smoking yields and actual human uptake	* The widely believed opinion that cigarettes with low yields, when in vitro tested, are less hazardous, must be questioned * For the majority of cigarette brands there is no defensible correlation between in vitro analytical machine yields and actual uptake and bioavailability * In one study, 52 percent of smokers admitted to having blocked the ventilation holes of low-yield cigarettes * A second study demonstrated that smokers automatically adjusted the actual nicotine dose of intake to some "optimum value" * In another study, plasma nicotine and COHb concentrations showed that the smokers compensated downward or upward for a switch to high yield or low yield cigarettes, respectively, for about two-thirds of the difference in standard yields when switched to either high or low-nicotine cigarettes	* In yet another study, plasma nicotine and cotinine levels demonstrated that subjects' compensation was partial and averaged 36 percent * One study showed that average nicotine intake per cigarette did not correlate with machine-determined yield		

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[redacted]	Epstein, L.H., et al.	Behavior Therapy (1981, volume 12, p. 507-519)	Study 1: 6 smokers in smoking reduction program (3 males and 3 females, mean age 31.8 years) * Study 2: 7 smokers (2 males and 5 females, mean age of 13.5 years)	* Study 1: One week to establish baseline, once per week during withdrawal, and at 2-week and 6-week intervals after treatment * Study 2: two 2-hour sessions	To better understand nicotine regulation by studying puff patterns of smokers when they are smoking cigarettes that vary in nicotine yield, or when they have the same cigarette available but serum nicotine levels are lowered during withdrawal or deprivation	* There were adjustments in smoking behaviors when cigarettes that vary in nicotine delivery were used, but not when serum nicotine was modified by withdrawal or deprivation * Inhalation patterns of individual cigarettes may not be sensitive to fluctuations in serum nicotine, while they are sensitive to cigarettes that vary in nicotine yield and draw resistance * Subjects take significantly more puffs on the low nicotine cigarette, smoke at a faster rate, hole each puff longer, smoke the cigarette in less time, take more total volume, and more volume/puff * Each subjects showed greater intake of the low nicotine cigarette than the high nicotine cigarette * Both group and individual results suggest that smoking behavior is stable across withdrawal phases * There were no differences in smoking topography in smoking the terminal cigarette after smoking four or no cigarettes during the two hours	* Subjects were asked to monitor and report urges to smoke, where and with whom a cigarette was smoked, and their general mood * Pressure transducer used to measure number of puffs per cigarette, length of time smoking the cigarette assessed from first to last puff, mean puff duration, total intake volume, and volume/puff * Heart rate was detected using EKG plate electrodes * Serum carboxyhemoglobins were determined using spectrophotometric procedures	ANOVA, Pearson product-moment correlation procedures	

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[redacted]	Griffths, R.R., and Henningfield, J.E.	Trends in Pharmacological Sciences (1982, volume 3, p. 260-263)			To report on the pharmacological effects of cigarette smoking	* Human cigarrete smoking is an orderly form of drug self-administration which is responsive to a variety of pharmacological manipulations * To the extent that smokers regulate their smoke intake, low yield cigarettes may produce compensating increases in smoking which, in turn, increase exposure to some of the toxic components of smoke * There is an increase in number of cigarettes smoked or rate of puffing with shortening of tobacco rod length, dilution of smoke with ventilated cigarette holders, or restriction fo the nubmer of uniform puffs available * Rate of smoking increases with deprivation or decreases with nicotine preloading * When the amount of smoke available to the smoker is manipualted ,the smoker tends to change his smoking behavior in the direction of maintaining his usual level of smoke exposure * Rapid onset of CNS effects and relatively short duration of action make nicotine an ideal pharmacological agent for controlling behavior →	* Nicotine can maintain self-administration in animals * There is a suppression of smoking after the administration of nicotine antagonists and after the substitution of nicotine-free cigarettes * Ratings of strength and satisfaction increase with increasing nicotine dose * When excretion of nicotine increases, the rate of smoking increases * Ethanol, opiod compounds, and D-amphetamine increase smoking * withdrawal causes a self-reported desire to smoke, impaired psychomotor performance, and irritability		
[redacted]	Hatsukami, D.K., Pickens, R.W., Svikis, D.S., and Hughes, J.r.	Addictive Behaviors (1988, volume 13, number 1, p. 91-95)	10 smokers (five male, five female, average age of 32.3 years)	Seven days	To determine the relationship between smoking topography and nicotine blood levels	* Change in pre- and post-cigarette nicotine levels and metabolic half-life for nicotine were not related to within-cigarette topography measures or nicotine yield of cigarette, but were significantly related to intercigarette interval * All 10 subjects demonstrated an increase in nicotine blood levels after smoking a cigarette * The greater the change in pre- and post cigarette nicotine blood levels, the longer the intercigarette interval * Subjects with longer half-life for nicotine have longer intercigarette intervals	* Blood samples analyzed for nicotine by raidoimmunoassay * Topographical features measured	Pearson correlation coefficients	Lack of between-subject variability in cigarette smoking yield; device for measuring topography not the most accurate measure

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[redacted]	Hee, J., et al.	Pharmacology, Biochemistry, and Behavior (1995, volume 52, number 1, p. 195-203)	198 (9 groups of 12 subjects, 43 males and 65 females, mean age of 22.7 years)	2 sessions	To determine the influence of cigarette yield and length of smoking experience on smoking behavior and biomarker levels	* COHb levels after the first cigarette in the morning increase significantly with CO cigarette yield and length of smoking experience * In the evening, only the cigarette yield has an effect on COHB level * Only COHB level and total urinary nicotine metabolites (Barlow index) are weakly correlated with cigarette yield * The strongest correlation is observed between Barlow index and COHb percentage, whatever the time of the day * The biomarkers, except thioethers and mutagens, are more generally affected by consumption and smoking parameters * Inhalation depth increases with decreasing cigarette yield and with length of smoking habit * Biomarker levels excreted in urine are generally lower for females than for males and tend to increase with smoking history	* Puff number, mean puff duration, mean puff volume, total smoke volume, mean puff interval, and total smoking duration measured with flowmeter associated with cigarette holder * COHb was measured indirectly from the CO concentration analyzed by infrared spectrometry in end tidal lair * An inhalation index of the ratio between the quantity of CO retained by the subject and that produced by the cigarette smoked was calculated * Urinary pH was measured and creatinine was determined according to the Jaffe method * Nicotine and its pyridinic metabolites measured by colorimetry * Nicotine and cotinine measurements made by gas chromatography * Thioethers measured by colorimetry * Mutagens determined by a microsuspension assay	BMDP statistical software used; ANOVA, multiple regression models	* The absence of significant differences due to cigarette class in urinary biomarkers can be explained by changes in inhalation depth, individual differences of metabolism, and limited specificity of some markers
[redacted]	Herning, R.I., Jones, R.T., Benowitz, N.L., and Mines, A.h.	Clinical Pharmacological Therapeutics (1983, volume 33, number 1, p. 84-90)	11 smokers (8 males and 3 females)	One session on one day or one session on each of two days	To determine the effect of smoking topography and machine determined nicotine yields on nicotine blood levels	* Indirect evidence suggests that smoking low-tar and nicotine cigarettes does not necessarily reduce exposure to these substances * Machine-determined nicotine yields of the cigarettes correlated with the increase in nicotine blood levels after smoking but, when individual differences in smoking behavior were taken into account along with the nicotine yield, there was a stronger correlation with nicotine blood levels	* Puff volume was the volume of smoke passing through a cigarette holder * Pressure transducer attached to holder to measure interpuff interval, number of puffs, and puff duration * Depth of inhalation was measured by mercury capillary strain gauges * Expired breath CO was measured before and after cigarettes with an Energetics Science CO analyzer * Presmoking blood and breath CO samples were taken * Blood samples were analyzed for nicotine concentrations by gas-liquid chromatography	Univariate linear regression analysis and multiple regression analysis (as well as log-linear regressions)	Persons smoking more or less often than the smokers tested might show different relationship; other subsets of smoking measures might give an even better relationship

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[redacted]	Herning, R.I., Jones, R.T., Nachman, J., and Mines, A.H.	British Medical Journal (1981, volume 283, p. 187-189)	24 smokers (14 male and 10 female, mean age of 30 years)	3 test days	To determine the effect of nicotine yield of cigarettes on smoking variables	* Smokers took longer puffs when smoking cigarettes delivering lower nicotine yields than their normal brands * The number of puffs and interval between puffs did not differ between nicotine doses * Subjects took more time to smoke high-nicotine cigarettes * Increase in heart rate was greater with high- and medium-nicotine levels than with low * Increase in breath CO concentrations after subjects had smoked was consistent with the increase in puff volume with these cigarettes * Mean volume of puffs decreased with each puff * Smokers, although they increased puff size, were either unable or unwilling to inhale enough smoke to compensate completely for the reduced nicotine yield	* Heart rate was recorded continuously * CO values obtained before and 30 minutes after with an Ecolyzer (Series 2000) * A checklist of mood and tobacco symptoms completed before and after smoking * Puff volume and duration, number of puffs, and interpuff interval were recorded with Stratham Model PM596	ANOVA	Subjects did not like the cigarettes because they were unfiltered, had no flavoring agents, and were dry; the high-nicotine cigarettes made subjects feel light-headed and shaky; CO concentration is found to be a good indicator of chronic plasma nicotine concentration but was not an indicator of nicotine intake from a single cigarette

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[redacted]	Hofer, I., Nil, R., and Battig, K.	Pharmacology, Biochemistry, and Behavior (1991, volume 40, p. 139-149)	72 males and 72 females	2 sessions	To determine the relationships between machine smoking nicotine yield and different smoke exposure investigators, to assess the stability of dependent measures over time, as well as to assess the impact of lip vs. flowmeter holder smoking and the unrestricted vs. standardized smoking of a cigarette	* For plasma nictoine, higher nicotine yield cigarettes produced higher presmoking levels * For plasma cotinine, higher nicotine yield cigarettes produced higher presmoking levels * There was no difference in respiratory CO for higher nicotine yield cigarettes * Pre- to postsmoking boosts of CO and nicotine increased with yield, but the differences were smalelr than those in yield * This partial compensation can be attributed to puffig behavior as revealed by the differences between yield classes with respoect to flowmeter measures (puff volume, flow parameters, number of puffs) * Contact condition (whether smoking with lip contact or with a flowmeter holder) hardly influenced results * Forced puffing revealed down regulation mechanisms in smoke absorption and, less pronounced, in puffing behavior * Cardiovascular and subjective effects were widely independent of yield * Plasma cotinine appeared as the best smoke exposure indicator, due both to its high retest relaibility and its relationship to nicotine yield	* CO concentrations were measured with a CO analyzer * Nicotine and cotinine concentrations in plasma were determined by a GC-MS method * The amount of nicotine in the filter was determined by a GC method * Puffing behavior was recorded automatically using a flowmeter, computerized to obtain puff duration, interpuff interval, puff volume, mean and peak flow, peak pressure, and latency from beginning of puff to peak pressure * Heart rate was recorded continuously via a photoplethysmogram * Questionnaire on smoking history and VAS about smoking satisfaction, characteristics, and effects	ANOVA, posteriori Scheffe-tests, Pearson correlations	Variability in measures depends considerably on sampling circumstances; possible that the smokers were already "low absorbers"; amount of tobacco smoked per cigarette varied; smoking with a cigarette holder instead of normal lip contact changes some aspects of smoke absorption, puffing behavior, and subjective effects of smoking; acute tolerance; emotional load caused by the implanted intravenous catheter

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[redacted]	Jarvik, M.E., et al.	Physiology and Behavior (1994, volume 56, issue 3, p. 563-570)	20 smokers (half menthol smokers, mean age 37.4 years)	2 sessions of 1-2 hours each	To assess the effect of menthol versus regular cigarettes on select chemical and topographic parameters and according to race	* Mentholated cigarettes produced a significantly greater boost in CO * Mentholated cigarettes decreased average and total cumulative puff volumes and increased mean puff flow rates of inhaled smoke * There was no significant differences in depth of inhalation of the smoke or in the amount of insoluble smoke particulates delivered to or retained in the respiratory trace * There were no race differences as far as chemical-topography relationship results were concerned * Mentholation may affect combustion of tobacco or perception of volume intake * Blacks typically inhale a greater volume of smoke	* Questionnaire on demographics and current smoking habits give * Fagerstrom Tolerance scale and Stanford Dependence scale given * Questionnaire about motivation for smoking given * Spirometer testing was given prior to test * The cigarette holder was fitted with a pressure transducer to measure puff flow and volume * Inductive plethysmography was used to measure inhaled volume and duration of breathhold * Filer on the cigarette holder and exhaled smoke were used to measure insoluble smoke particulates * Interpuff interval derived from other topography measurements * Blood samples were taken using an IV catheter * CO-oximeter was used to measure carboxyhemoglovin * CO-Analyzer was used to measure end-expired CO levels * Cigarette butts retained	Subject averages taken; inhaled volume adjusted to get forced vital capacity; 3-way ANOVAs performed	
[redacted]	Lader, M.	British Journal of Clinical Pharmacology (1978, volume 5, p. 289-292)			To review studies on nicotine's effect on smoking behavior	* Nicotine first stimulates and at higher doses depresses the activity of cholinoceptors in autonomic ganglia and nueromuscualr junction * Nicotine releases catecholamines from the adrenal medulla and other sites * Nicotine depresses spinal reflexes, excites respiration through stimulation fo the carotid body, and activates the electroencephalogia * Heart rate increases, blood pressure increases, muscle blood flow increases, skin blood flow decreases, and adrenaline excretion increases with nicotine * Nicotine increases slow-wave electroencephalographic activity, decreases alpha activity, and increases beta activity * Task performance is disrupted with nicotine * Smoking improves performance in the low-arousal test in the low-arousal smokers (those who smoke to alter themselves or to combat boredom) but slightly impaired it in the high-arousal smokers (those who smoke to calm themselves) and vice-versa for high-arousal tasks →	* Heavy smokers tend to puff more n their cigarettes under low-arousal condition, but nitoctine intake altered * Withdrawal and tolerace effects are seen, but whether they are related solely to nicotine is unknown * There is a decrease in the number of cigarettes smoked, time smoked, and puff frequency with an increase in nicotine yield * It is impossible for the average smoker to increase his smoking sufficiently to compensate fully for the low content of low-nicotine cigarettes * The nubmer of cigarettes per day of smokers is unaffected by tar content * Smokers detected differences in the strength of cigarettes based on nicotine and not tar content * Interindividual variation important * Nicotine hums have evaried effects on smoking behavior * Forced intake of nicotine by injection not as strong as should be * Nicotine agnoists and antagnoists affect smoking behavior * Cotinine and urinary pH measurements are good indicators of nicotine intake		

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[redacted]	Nil, R., and Battig, K.	Psychopharmacology (1989, volume 99, p. 54-59)	15 regular smokers (11 female and 4 male)	7 sessions	To compare independently the influence of different cigarette smoke taste categories and different machine standard smoke yield values on cigarette smoking behavior and related subjective measures	* Although general acceptability of the cigarettes, smoking satisfaction, and pleasantness of taste were clearly lower for all test cigarettes as opposed to the habitual brand reference cigarettes, these measures remained unaffected by taste or smoke yield of the test cigarettes * Harshness of smoke was higher in the dark tobacco category and generally decreased with the lower smoke yield cigarettes * Independent effects of taste and smoke yield were obtained for total puff volume, inhalation time and CO absorption, suggesting for a compensatory intensification of smoking behavior for low yield cigarettes and an independent increase of smoking intensity from mentholated to dark tobacco to blond tobacco	* Puffing patterns were analyzed using a puff flowmeter (puff volume, puff duration, and puff interval) * Respiration was continuously recorded on the minicomputer by means of the transthorax impedence method to get postpuff inspiratory latency, postpuff inspiratory time, and postpuff inspiratory amplitude * Mixed expiratory tidal CO air analyzed with a CO analyser * An infrared transducer was used to record signals of the vascular pulse wave for analysis of heart rate * Analog scales were used to assess subjective ratings of smoking satisfaction, need, and taste	ANOVAs, t-tests; polynomial regression analyses (BMDP)	* Measures of inhalation volumes dependent on subject position and were widely insensitive; usefulness of alveolar CO boost questionable
[redacted]	Nil, R., Buzzi, R., and Battig, K.	Pharmacology, Biochemistry, and Behavior (1986, volume 24, issue 3, p. 587-595)	117 regular smokers (69 male, 48 female)	One 90 minute session	To determine the effect of cigarette yields on topography measures, smoking behavior, and smoking absorption	* Pre- to postsmoking CO boost remained unrelated to the smoke deliveries of the cigarettes in both comparisons (interindividual and switching) * Estimated mouth intake of nicotine was strongly dependent on the smoke yield variables of the cigarette but remained uncorrelated with CO absorption * Discrepancies between mouth smoke intake and alveolar smoke absorption could not be explained by the volumes or durations of the postpuff respiratory cycle * Females had a lower blood pressure and smoked lighter cigarettes than men * There was an increases in puff volume with the lighter cigarettes * There was some compensation for differing nicotine yields, mainly among puffing variables * There were some sex differences in how cigarette yield affected smoking behavior	* A puff flowmeter with a pressure transducer and digital analyzer were used to determine puff volume, puff duration, puff interval, peak pressure, latency to peak pressure, and peak flow * Standard machine smoking data was used to estimate CO and nicotine mouth intake * A Co Analyzer was used to measure CO concentration in expiratory tidal air * Respiratory movements were recorded by the transthoracx impedance method * A dry spirometer was used to calibrate quantitatively the inspiratory and expiratory amplitudes of the thorax impendence signals to give postpuff inspiratory latency, postpuff inspiratory volume and duration * Blood pressure and pulse rate were measured with the module Elag Re 207-5 * A questionnaire on smoking behavior was given * WAS used to assess subjective need for smoking and smoking satisfaction	SPSS and BMDP software was used; cross-sectional correlations; comparisons of means by t test method; multiple regression analysis	Subjects recognized low yield cigarettes immediately and rated them as less satisfactory

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The Measurement of Human Smoking Behavior and Influence Smoking	Reeves, N., and Dixon, M.	Report of the Joint Meeting of the Smoke and Technology Groups (1995, AVII)	18 regular consumers of 15 mg products, 21 of 9 mg products, and 40 of 6 mg products	One session smoking two cigarettes with 20 minute breaks in between	To examine and compare the smoking behavior patterns of 3 groups of smokers whose "own brand" products were of different tar yield	* Puff volumes, pressures, and durations were similar for all 3 groups of smokers * Puff numbers were marginally higher in the 6 mg group than in the other two * All 3 group exhibited a similar downward tend on puff volume and duration with increasing puff number * There were no marked differences in the behavior patterns of smokers of products differing in their tar and nicotine deliveries * The tobacco rod acts as a filter for smoke particulates and the progressive puff-by-puff increase in FDPM and nicotine delivery occurs primarily as a result of reduction in rod filtration as the rod shortens	* Flow rate through cigarette and pressure applied to cigarette during puff process measured by attaching cigarette to a holder incorporating an orifice plate and with two pressure points, all connected to a computerized program	Means given	Smokers unfamiliar with a product of lower delivery may smoke in a more intense manner for other sensory reasons
	Russell, M.A.H.	Progress in Brain Research (1989, volume 79, p. 289-302)			To describe advances in the literature on the physiological and psychosocial effects of nicotine on individual smoking behavior	* Nicotine's role in as the primary and controlling factor in smoking has now been firmly established by evidance from three main areas of behavioral research: role as primary reinforcer, its controlling influence in the self-regulation of smoke intake, and its effects on the cigarette withdrawal syndrome * Smokers downregulate their nicotine intake with great precision to avoid the toxic aversive effects of exceeding their usual blood nicotine levels, but up-regulation to maintain usual smoking levels is far less precise * Chronic exposure to nicotine induces an increase in the number of nicotinic cholinergic receptors in many parts of the brain, indicating the presence of structural as well as functional changes in the brain and nervous system of smokers * Sensory adaptation and tolerance to aversive effects develops rapidly * "Stimulation," "sedative," "addictive," and "automatic" motivation factors all correlate most highly with cigarette consumption	* Three-stage model of dependence: psychosocial motives; smoking for pleasurable, calming, and mildly stimulant effects of nicotine and habit; and need to stave off withdrawal * Nicotine intake from a cigarette depends on the intensity of puffing and the depth of inhalation * In view of the 2-h elimination half-life, significant cumulative build-up of nicotine levels occurs even at a modest frequency of smoking * It is pharmokinetically impossible to exceed a certain blood nicotine level * There is chronic partial blockade of the agonist effects of nicotine at postsynaptic cholinergic receptors * Due to the development of acute tolerance, smokers experience little positive impact from individual cigarettes under steady-state condition but do once deprived * The subjective and behavioral effects of nicotine in humans differ markedly, not only between individuals but also within individuals, according to the stage of their smoking career, their level of dependence and the time since their last few doses		

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[redacted]	Sutton, S.R., et al.	British Medical Journal (1982, volume 285, p. 600-603)	55 smokers	One time (during afternoon or evening)	To examine the relationship between cigarette yields, puffing patterns, and blood nicotine and COHb concentrations in a sample of smokers smoking their usual brand of cigarette	* Total volume of smoke puffed from a cigarette was a more important determinant of peak blood nicotine cocnentration than the nicotine or tar yield of the cigarette, its length, or the reported nubmer of cigarettes smoked on the test day * When nicotine yield was controlled for, smokers of lower tar cigarettes not only puffed more smoke from their cigarettes than smokers of higher-tar cigarettes but they also had higher plasma nicotine concentrations, suggesting that they were compesnating for the reduced delivery of tar by puffing and inhaling a greater volume of smoke * The results based on carboxyhemoglobin concentrations were consistent with this interpretation * CO yield was the onyl variable to have a signficiant effect on carboxyhemoglobin levels * Subjects who had not smoked for more than half an hour tended to puff more intensely * Older people puffed less than younger people and women puffed more than men	* Subjects kept a record of their cigarette consumption that day up until the time of arrival and collected a sample of their butts * A puff analyser was used to measure number of puffs taken, the volume, pressure and duration of each puff, the itnerpuff intervals, and the time taken to smoke the cigarette * Blood samples were analyzed for COHb using an IL-182 Co-oximeter * Plasma nicotine concentrations were measured using gas chromatography	Regression Analysis	

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E... Puff ... S... C... M... C... C...	Weinhold, L.L., and Stitzer, M.L.	Pharmacology, Biochemistry, and Behavior (1989, volume 33, number 4. p. 853-858)	6 smokers (mean age of 36.3)	27 smoking trials for first experiment, 9 trials for second experiment (3 trials per day)	To further clarify how smoking behaviors (puff number and puff spacing) can influence biological exposure to CO from commercial brand cigarettes	* CO exposure (pre- to postsmoking increments) was directly related to the number f puffs taken for all cigarette yields * CO exposure from the high- and low-yield cigarettes was equivalent when the number of puffs taken from the low-yield cigarettes was increased by 50% * In contrast, CO exposure from ultralow-yield cigarettes was still marginally lower than exposure from high-yield cigarettes after a 4-fold increase in puff number * Puff spacing did not affect biological exposure to CO * The number of puffs taken during smoking can clearly affect biological exposure to CO, but compensation for lowered yield using increased puffs is much more difficult when ultralow- as compared with low or "light"-yield cigarettes are smoked	* Puff-respiratory cycles were recorded in real time * Puff number, interpuff interval, puff volume, inhalation duration, inhalation volume, and lung exposure duration were measured with flowmeter and Respitrace outputs * Expired end-air CO samples analyzed for CO content using an Ecolyzer 2000 * Vital capacity determined using a water spirometer	ANOVAs, Tukey's post-hoc tests	It is possible that puff flow rates may influence exposure and that nicotine levels might show effects that are not seen with CO analysis alone; respiratory system may not be able to absorb all the CO available from smoke of high-yield cigarettes during brief lung exposure times characteristic of cigarette smoking; filter-vent blocking plays a role in compensation

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Literature Review on Topography

Publication Title	Authors	Journal Citation	Population Sample Size	Duration of Study	Study Objectives	Results and Conclusions	Methods of Measurement	Statistical Analysis	Mention of Confounde
	Ashton, H., Watson, D.W., Marsh, R., and Sadlers, J.	British Medical Journal (1970, volume 3, p. 679-681)	36 smokers (15 females and 21 males, 19-35 years old)	One time	To determine the effect of puffing on nicotine intake and compensation	* Smokers of cigarettes with high-retention filters took more frequent puffs and obtained nearly the same amount of nicotine as smokers of cigarettes with low-retention filters, both while performing the tasks and during the resting period * Smokers of both types of cigarettes took significantly more puffs and obtained more nicotine per unit time during the resting period than during the tasks * It is possible that smokers automatically adjust the nicotine dose obtained from a cigarette to some "optimum" level which may vary with different activities	* Each puff at a cigarette was recorded by an observer and time of start and finish of each cigarette was noted * Cigarette stubs were analyzed for nicotine content (nicotine presented to smoker) * Respiratory rate was measured by impedance pneumography by means of two Devices skin electrodes and recorded on a Beckman Dynograph recorder * Subjects' reaction times to the panel light signals during the task, and physiological functions including heart rate, blood pressure, and calf blood flow were also recorded	t-tests	
	Battig, K., Buzzi, R., and Nil, R.	Psychopharmacology (1982, volume 76, p. 139-148)	67 male and 43 female smokers (16-78 years old)	90 minute session	To compare puffing behavior quantitatively across smokers of different types of cigarettes and to estimate inhalation by measure both CO yield of the cigarettes and CO levels in expiratory tidal air	* Puff shape, puff volume, and puff frequency accounted for about 50% of variation obtained with the different puffing variables * Expiratory tidal CO levels increased with the number of cigarettes smoked before the tests and with the intensity of the smoking habit, but pre- to postsmoking change in tidal CO differences were similar for smokers of all types of cigarettes * Volume compensation for differences of smoke yield fo the cigarettes was generally morep ronounced in women than in men, and, additionally, it was more pronounced for cigarettes with standard smoke nicotine yield below 0.9 mg for both sexes * Only for women, partial correlation procedures suggested that nicotine might be more important in determining puffing behavior than CO and condensate yield, but there were also no women smoking the strongest cigarettes * Personality ratings, pulmonary functions, and cardiovascular functions were not, or only inconsistently, correlated with puffing behavior or type of cigarette	* A cigarette holder-puffing flow meter was used to determine puffing flow and pressure * Module developed to analyze puff volume, puff duration, peak pressure, latency to peak pressure, and interval from the preceding puff * Expiratory tidal air collected and analyzed with Ambient CO Monitoring System * Module Hopsital-Calculair used to monitor forced vital capacity, forced 1-s expiratory volume, and peak flow * Module Elag Be-297-S was used to measure pulse rate and blood pressure * Questionnaires on drug usage, demographics, and personality	Correlational analysis; factor analysis; discriminant analysis; and partial correlation procedures	Intersex differences in puffing behavior

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[redacted]	Benowitz, N.L., et al.	New England Journal of Medicine (1983, volume 309, p. 139-142)	272 (122 males, 150 females, average age of 37, all about to begin a smoking treatment program)	One time	To determine whether or not the measured yield of a cigarette corresponds to actual consumption of nicotine (As measured by blood cotinine levels)	* Nicotine concentration in tobacco inversely correlated with the concentrations measured by smoking machines * Blood cotinine concentrations correlated with the number of cigarettes smoked per day but not with nicotine yield * Because of long half-life, cotinine concentrations vary relatively throughout a day of smokign and thus are a consistent measure of nicotine exposure * Blood cotinine concentration si not a perfect marker of nciotine consumption, because of individual variability in both the conversion of nicotine to cotinine and the elimination rate of cotinine itself * The main determinants of whether a cigarette has a low or a high yield in machine testing are the charactertistics of its ventilation and burning * These variables are under the control fo the cigarette smoker * Blood cotinine concentration is nto a perfect marker of nicotine consumption, because of individual variability in both the conversion fo nicotine to cotinine and the elimination rate of cotinine itself	* Nicotine concentrations measured by high performance liquid chromatography * Blood samples were taken and measured for nicotine and cotinine intake with gas chromatography	Univariate linear regression and hierarchical multiple linear regression	Smokers who participated in this study were seeking treatment; blood cotinine concentration is not a perfect marker of nicotine consumption because of individual variability in both the conversion of nicotine to cotinine and the elimination rate of cotinine itself

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	Bridges, R.B., et al.	Pharmacology, Biochemistry, and Behavior (1990, volume 37, p. 29-39)	170 male smokers (mean age of 37.8)	One time	To determine if differences in puffing topography were associated with cigarette yield and to determine the relationships of puffing topography with population or smoking history characteristics and smoke exposure or absorption	* Of the puffing topography variables, interpuff interval appeared to be the primary determinnat of blood concentrations of smoke constitutents * Smokers of low nicotine yield cigarettes partially compesnated for these lower yeilds by increasign the ttoal volume puffed per cigarette * Observed fifferences in puffing topography associated with increased daily cigarette consumption and cumulative smokign history were consistent with a higher smoke exposure per cigarette * Although both alcohol and coffee consumption are associated with present and cumulative smoking history, coffee consumption is uniquely associated with differences in puffing topography consistent with a higher smoke exposure per cigarette * Neither coffee nor alcohol consumption histories added significantly to the prediction of blood concentrations of smoke constituents over that obtained by smoking history and puffing topography	* Questionnaire on health, smoking and drug usage, and alcohol and coffee consumption * Pressure transducer attached to cigarette holder used to calculate the number of puffs per cigarette, interpuff interval, duration and volume of each puff, mean volume and duration per puff, and total puff volume and duration per cigarette * Serum thiocynate and blood carboxyhemoglobin were determined spectrophotometrically, while plasma nicotine and cotinine concentrations were determined by radioimmunoassay	ANOVA, univariate and multivariate analyses	Cigarette holder pneumotachograph, smoking setting, and time since last cigarette can influence puffing behavior; interindividual variability
	Bucchalter, A.R., and Eissenberg, T.	Nicotine and Tobacco Research (2000, volume 2, p. 39-43)	10 light or ultra-light cigarette smokers (mean age of 23.2 years, 7 female and 3 male)	Two 2-hour sessions	To determine the effects of Accord on subjective and physiological measures and smoking behavior	* When using the Accord, the magnitude of smoking-induced craving reductions and the physiological effects of smoking were less, and puff volume and frequency were greater than when subjects smoked their own brand of cigarettes * The expired air CO increases after smoking own brand cigarettes did not occur after using the Accord * The Accord may deliver nicotine less efficiently that normally marketed cigarettes * compensation may occur * Heart rate increase less with Accord * Skin temperature decreased less with Accord * Interpuff intervals were shorted with Accord * Puff volume and duration were greater with Accord	* Breath CO sample was taken * Fagerstrom nicotine tolerance questionnaire given * VAS subject-rated measures on withdrawal symptoms * Questionnaire of Smoking Urges (intention to smoke and anticipation of relief from withdrawal) * Heart rate, skin temperature, and blood pressure measured with Noninvasive Patient and monitor model 507E * Expired CO levels were taken before and after each cigarette with Breath CO monitor * Topography data was computerized and a pressure transducer used to measure puff volume, puff duration, puff number, and interpuff interval	ANOVA; Hunh-Feldt corrections; Tukey's significantly different test	Subjects were only mildly dependent; received only acute exposure to the novel system; were not blind to smoking condition; no placebo condition; small sample size

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[redacted]	Bucchalter, A.R., Schrinel, L., and Eissenberg, T.	Nicotine and Tobacco Research (2001, volume 3, p. 111-118)	16 female and 16 male smokers of light or ultra-light cigarettes (mean age of 25.9 years)	Four 2.5 hour sessions	To determine the effect of the Accord cigarette on withdrawal of suppression and biomarkers of exposure	* Withdrawal suppression, CO intake, and tachycardia produced by Accord are all less than that produced by normally marketed cigarette brands, even controlling for the system's 8-puff limitation and for brand preference * Incomplete withdrawal suppression may increase smoking frequency, thus potentially offsetting any decreased risks associated with Accord use * Greater reductions in subjective craving and QSU scores were observed when subjects took their puffs from normally market brands as opposed to the Accord	* CO breath screening at start * Nicotine dependency measured by Fagerstrom nicotine tolerance questionnaire * Quit attempts history taken * VAS scale to measure tobacco withdrawal symptoms * Questionnaire of Smoking Urges * Heart rate and skin temperature monitored continuously using the Noninvasive Patient Monitor 507E * CO measured before and after each cigarette using breath CO monitor * Topography data was computerized using pressure transducer to get puff volume, duration, and interpuff interval	Mixed ANOVAs; Huynh–Feld corrections; Tukey's significantly different test	Some subjects had sessions at different times of the day; the use of only smokers of light and ultra-light cigarettes limited; subjects were not familiar with Accord system; no control for menstrual cycle phase
[redacted]	Burns, D.M.	US Consumer Product Safety Commission contract			To review and give recommendations for analyses of low-ignition cigarettes and toxicity and carcinogenicity	* A number of changes contemplated to reduce the potential of cigarettes (e.g., higher porosity paper, less densely packed tobacco, different tobacco blends) may alter the chemical composition of the smoke, potentially changing its toxicity and carcinogenicity, as well as topography * Any new agent added to the cigarette, and its pryolysis products, have the potential to increase the toxicity of the smoke or to add qualitatively different toxicities * smokers who smoke lower yield cigarettes compensate by changing puff volume and frequency * The short half-life CO in the blood means that the levels are heavily influenced by the intensity of smoking in the hours immediately prior to measurement →	* Nicotine and cotinine levels are very specific measures of exposure to tobacco smoke, and cotinine levels are the most widely accepted measure of smoking status and the amount of smoke retained is imprecise * recommends a brand-to-brand comparison of risk using machine testing, bioassay testing, a listing of additives used in the cigarette brand, and, finally, human testing		

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[redacted]	Diding, N.	International Journal of clinical Pharmacology, Therapy, and Toxicology (1987, volume 25, number 3, p. 143-147)			To review recent studies on plasma concentrations and the application of pharmokinetic parameters in human smoking, self-regulation and compensation when switching between different brands, and the relationship between in vitro machine smoking yields and actual human uptake	* The widely believed opinion that cigarettes with low yields, when in vitro tested, are less hazardous, must be questioned * For the majority of cigarette brands there is no defensible correlation between in vitro analytical machine yields and actual uptake and bioavailability * In one study, 52 percent of smokers admitted to having blocked the ventilation holes of low-yield cigarettes * A second study demonstrated that smokers automatically adjusted the actual nicotine dose of intake to some "optimum value" * In another study, plasma nicotine and COHb concentrations showed that the smokers compensated downward or upward for a switch to high yield or low yield cigarettes, respectively, for about two-thirds of the difference in standard yields when switched to either high or low-nicotine cigarettes	* In yet another study, plasma nicotine and cotinine levels demonstrated that subjects' compensation was partial and averaged 36 percent * One study showed that average nicotine intake per cigarette did not correlate with machine-determined yield		

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	Epstein, L.H., et al.	Behavior Therapy (1981, volume 12, p. 507-519)	Study 1: 6 smokers in smoking reduction program (3 males and 3 females, mean age 31.8 years) * Study 2: 7 smokers (2 males and 5 females, mean age of 13.5 years)	* Study 1: One week to establish baseline, once per week during withdrawal, and at 2-week and 6-week intervals after treatment * Study 2: two 2-hour sessions	To better understand nicotine regulation by studying puff patterns of smokers when they are smoking cigarettes that vary in nicotine yield, or when they have the same cigarette available but serum nicotine levels are lowered during withdrawal or deprivation	* There were adjustments in smoking behaviors when cigarettes that vary in nicotine delivery were used, but not when serum nicotine was modified by withdrawal or deprivation * Inhalation patterns of individual cigarettes may not be sensitive to fluctuations in serum nicotine, while they are sensitive to cigarettes that vary in nicotine yield and draw resistance * Subjects take significantly more puffs on the low nicotine cigarette, smoke at a faster rate, hole each puff longer, smoke the cigarette in less time, take more total volume, and more volume/puff * Each subjects showed greater intake of the low nicotine cigarette than the high nicotine cigarette * Both group and individual results suggest that smoking behavior is stable across withdrawal phases * There were no differences in smoking topography in smoking the terminal cigarette after smoking four or no cigarettes during the two hours	* Subjects were asked to monitor and report urges to smoke, where and with whom a cigarette was smoked, and their general mood * Pressure transducer used to measure number of puffs per cigarette, length of time smoking the cigarette assessed from first to last puff, mean puff duration, total intake volume, and volume/puff * Heart rate was detected using EKG plate electrodes * Serum carboxyhemoglobins were determined using spectrophotometric procedures	ANOVA, Pearson product-moment correlation procedures	

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	Griffiths, R.R., and Henningfield, J.E.	Trends in Pharmacological Sciences (1982, volume 3, p. 260-263)			To report on the pharmacological effects of cigarette smoking	* Human cigarrete smoking is an orderly form of drug self-administration which is responsive to a variety of pharmacological manipulations * To the extent that smokers regulate their smoke intake, low yield cigarettes may produce compensating increases in smoking which, in turn, increase exposure to some of the toxic components of smoke * There is an increase in number of cigarettes smoked or rate of puffing with shortening of tobacco rod length, dilution of smoke with ventilated cigarette holders, or restriction fo the nubmer of uniform puffs available * Rate of smoking increases with deprivation or decreases with nicotine preloading * When the amount of smoke available to the smoker is manipualted ,the smoker tends to change his smoking behavior in the direction of maintaining his usual level of smoke exposure * Rapid onset of CNS effects and relatively short duration of action make nicotine an ideal pharmacological agent for controlling behavior →	* Nicotine can maintain self-administration in animals * There is a suppression of smoking after the administration of nicotine antagonists and after the substitution of nicotine-free cigarettes * Ratings of strength and satisfaction increase with increasing nicotine dose * When excretion of nicotine increases, the rate of smoking increases * Ethanol, opiod compounds, and D-amphetamine increase smoking * withdrawal causes a self-reported desire to smoke, impaired psychomotor performance, and irritability		
	Istsukami, D.K., Pickens, R.W., Svikis, D.S., and Hughes, J.r.	Addictive Behaviors (1988, volume 13, number 1, p. 91-95)	10 smokers (five male, five female, average age of 32.3 years)	Seven days	To determine the relationship between smoking topography and nicotine blood levels	* Change in pre- and post-cigarette nicotine levels and metabolic half-life for nicotine were not related to within-cigarette topography measures or nicotine yield of cigarette, but were significantly related to intercigarette interval * All 10 subjects demonstrated an increase in nicotine blood levels after smoking a cigarette * The greater the change in pre- and post cigarette nicotine blood levels, the longer the intercigarette interval * Subjects with longer half-life for nicotine have longer intercigarette intervals	* Blood samples analyzed for nicotine by raidoimmunoassay * Topographical features measured	Pearson correlation coefficients	Lack of between-subject variability in cigarette smoking yield; device for measuring topography not the most accurate measure

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[redacted]	Hee, J., et al.	Pharmacology, Biochemistry, and Behavior (1995, volume 52, number 1, p. 195-203)	198 (9 groups of 12 subjects, 43 males and 65 females, mean age of 22.7 years)	2 sessions	To determine the influence of cigarette yield and length of smoking experience on smoking behavior and biomarker levels	* COHb levels after the first cigarette in the morning increase significantly with CO cigarette yield and length of smoking experience * In the evening, only the cigarette yield has an effect on COHB level * Only COHB level and total urinary nicotine metabolites (Barlow index) are weakly correlated with cigarette yield * The strongest correlation is observed between Barlow index and COHb percentage, whatever the time of the day * The biomarkers, except thioethers and mutagens, are more generally affected by consumption and smoking parameters * Inhalation depth increases with decreasing cigarette yield and with length of smoking habit * Biomarker levels excreted in urine are generally lower for females than for males and tend to increase with smoking history	* Puff number, mean puff duration, mean puff volume, total smoke volume, mean puff interval, and total smoking duration measured with flowmeter associated with cigarette holder * COHb was measured indirectly from the CO concentration analyzed by infrared spectrometry in end tidal lair * An inhalation index of the ratio between the quantity of CO retained by the subject and that produced by the cigarette smoked was calculated * Urinary pH was measured and creatinine was determined according to the Jaffe method * Nicotine and its pyridinic metabolites measured by colorimetry * Nicotine and cotinine measurements made by gas chromatography * Thioethers measured by colorimetry * Mutagens determined by a microsuspension assay	BMDP statistical software used; ANOVA, multiple regression models	* The absence of significant differences due to cigarette class in urinary biomarkers can be explained by changes in inhalation depth, individual differences of metabolism, and limited specificity of some markers
[redacted]	Herning, R.I., Jones, R.T., Benowitz, N.L., and Mines, A.h.	Clinical Pharmacological Therapeutics (1983, volume 33, number 1, p. 84-90)	11 smokers (8 males and 3 females)	One session on one day or one session on each of two days	To determine the effect of smoking topography and machine-determined nicotine yields on nicotine blood levels	* Indirect evidence suggests that smoking low-tar and nicotine cigarettes does not necessarily reduce exposure to these substances * Machine-determined nicotine yields of the cigarettes correlated with the increase in nicotine blood levels after smoking but, when individual differences in smoking behavior were taken into account along with the nicotine yield, there was a stronger correlation with nicotine blood levels	* Puff volume was the volume of smoke passing through a cigarette holder * Pressure transducer attached to holder to measure interpuff interval, number of puffs, and puff duration * Depth of inhalation was measured by mercury capillary strain gauges * Expired-breath CO was measured before and after cigarettes with an Energetics Science CO analyzer * Presmoking blood and breath CO samples were taken * Blood samples were analyzed for nicotine concentrations by gas-liquid chromatography	Univariate linear regression analysis and multiple regression analysis (as well as log-linear regressions)	Persons smoking more or less often than the smokers tested might show different relationship; other subsets of smoking measures might give an even better relationship

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[redacted]	Herning, R.I., Jones, R.T., Nachman, J., and Mines, A.H.	British Medical Journal (1981, volume 283, p. 187-189)	24 smokers (14 male and 10 female, mean age of 30 years)	3 test days	To determine the effect of nicotine yield of cigarettes on smoking variables	* Smokers took longer puffs when smoking cigarettes delivering lower nicotine yields than their normal brands * The number of puffs and interval between puffs did not differ between nicotine doses * Subjects took more time to smoke high-nicotine cigarettes * Increase in heart rate was greater with high- and medium-nicotine levels than with low * Increase in breath CO concentrations after subjects had smoked was consistent with the increase in puff volume with these cigarettes * Mean volume of puffs decreased with each puff * Smokers, although they increased puff size, were either unable or unwilling to inhale enough smoke to compensate completely for the reduced nicotine yield	* Heart rate was recorded continuously * CO values obtained before and 30 minutes after with an Ecolyzer (Series 2000) * A checklist of mood and tobacco symptoms completed before and after smoking * Puff volume and duration, number of puffs, and interpuff interval were recorded with Stratham Model PM596	ANOVA	Subjects did not like the cigarettes because they were unfiltered, had no flavoring agents, and were dry; the high-nicotine cigarettes made subjects feel light-headed and shaky; CO concentration is found to be a good indicator of chronic plasma nicotine concentration but was not an indicator of nicotine intake from a single cigarette

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[redacted]	Hofer, I., Nil, R., and Battig, K.	Pharmacology, Biochemistry, and Behavior (1991, volume 40, p. 139-149)	72 males and 72 females	2 sessions	To determine the relationships between machine smoking nicotine yield and different smoke exposure investigators, to assess the stability of dependent measures over time, as well as to assess the impact of lip vs. flowmeter holder smoking and the unrestricted vs. standardized smoking of a cigarette	* For plasma nictoine, higher nicotine yield cigarettes produced higher presmoking levels * For plasma cotinine, higher nicotine yield cigarettes produced higher presmoking levels * There was no difference in respiratory CO for higher nicotine yield cigarettes * Pre- to postsmoking boosts of CO and nicotine increased with yield, but the differences were smalelr than those in yield * This partial compensation can be attributed to puffig behavior as revealed by the differences between yield classes with respoect to flowmeter measures (puff volume, flow parameters, number of puffs) * Contact condition (whether smoking with lip contact or with a flowmeter holder) hardly influenced results * Forced puffing revealed down regulation mechanisms in smoke absorption and, less pronounced, in puffing behavior * Cardiovascular and subjective effects were widely independent of yield * Plasma cotinine appeared as the best smoke exposure indicator, due both to its high retest relaibility and its relationship to nicotine yield	* CO concentrations were measured with a CO analyzer * Nicotine and cotinine concentrations in plasma were determined by a GC-MS method * The amount of nicotine in the filter was determined by a GC method * Puffing behavior was recorded automatically using a flowmeter, computerized to obtain puff duration, interpuff interval, puff volume, mean and peak flow, peak pressure, and latency from beginning of puff to peak pressure * Heart rate was recorded continuously via a photoplethysmogram * Questionnaire on smoking history and VAS about smoking satisfaction, characteristics, and effects	ANOVA, posteriori Scheffe-tests, Pearson correlations	Variability in measures depends considerably on sampling circumstances; possible that the smokers were already "low absorbers"; amount of tobacco smoked per cigarette varied; smoking with a cigarette holder instead of normal lip contact changes some aspects of smoke absorption, puffing behavior, and subjective effects of smoking; acute tolerance; emotional load caused by the implanted intravenous catheter

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[redacted]	Jarvik, M.E., et al.	Physiology and Behavior (1994, volume 56, issue 3, p. 563-570)	20 smokers (half menthol smokers, mean age 37.4 years)	2 sessions of 1-2 hours each	To assess the effect of menthol versus regular cigarettes on select chemical and topographic parameters and according to race	* Mentholated cigarettes produced a significantly greater boost in CO * Mentholated cigarettes decreased average and total cumulative puff volumes and increased mean puff flow rates of inhaled smoke * There was no significant differences in depth of inhalation of the smoke or in the amount of insoluble smoke particulates delivered to or retained in the respiratory trace * There were no race differences as far as chemical-topography relationship results were concerned * Mentholation may affect combustion of tobacco or perception of volume intake * Blacks typically inhale a greater volume of smoke	* Questionnaire on demographics and current smoking habits give * Fagerstrom Tolerance scale and Stanford Dependence scale given * Questionnaire about motivation for smoking given * Spirometer testing was given prior to test * The cigarette holder was fitted with a pressure transducer to measure puff flow and volume * Inductive plethysmography was used to measure inhaled volume and duration of breathhold * Filer on the cigarette holder and exhaled smoke were used to measure insoluble smoke particulates * Interpuff interval derived from other topography measurements * Blood samples were taken using an IV catheter * CO-oximeter was used to measure carboxyhemoglovin * CO-Analyzer was used to measure end-expired CO levels * Cigarette butts retained	Subject averages taken; inhaled volume adjusted to get forced vital capacity; 3-way ANOVAs performed	
[redacted]	Lader, M.	British Journal of Clinical Pharmacology (1978, volume 5, p. 289-292)			To review studies on nicotine's effect on smoking behavior	* Nicotine first stimulates and at higher doses depresses the activity of cholinoceptors in autonomic ganglia and nueromuscualr junction * Nicotine releases catecholamines from the adrenal medulla and other sites * Nicotine depresses spinal reflexes, excites respiration through stimulation fo the carotid body, and activates the electroencephalogia * Heart rate increases, blood pressure increases, muscle blood flow increases, skin blood flow decreases, and adrenaline excretion increases with nicotine * Nicotine increases slow-wave electroencephalographic activity, decreases alpha activity, and increases beta activity * Task performance is disrupted with nicotine * Smoking improves performance in the low-arousal test in the low-arousal smokers (those who smoke to alter themselves or to combat boredom) but slightly impaired it in the high-arousal smokers (those who smoke to calm themselves) and vice-versa for high-arousal tasks →	* Heavy smokers tend to puff more n their cigarettes under low-arousal condition, but nitoctine intake altered * Withdrawal and tolerace effects are seen, but whether they are related solely to nicotine is unknown * There is a decrease in the number of cigarettes smoked, time smoked, and puff frequency with an increase in nicotine yield * It is impossible for the average smoker to increase his smoking sufficiently to compensate fully for the low content of low-nicotine cigarettes * The nubmer of cigarettes per day of smokers is unaffected by tar content * Smokers detected differences in the strength of cigarettes based on nicotine and not tar content * Interindividual variation important * Nicotine hums have evaried effects on smoking behavior * Forced intake of nicotine by injection not as strong as should be * Nicotine agnoists and antagnoists affect smoking behavior * Cotinine and urinary pH measurements are good indicators of nicotine intake		

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[redacted]	Nil, R., and Battig, K.	Psychopharmacology (1989, volume 99, p. 54-59)	15 regular smokers (11 female and 4 male)	7 sessions	To compare independently the influence of different cigarette smoke taste categories and different machine standard smoke yield values on cigarette smoking behavior and related subjective measures	* Although general acceptability of the cigarettes, smoking satisfaction, and pleasantness of taste were clearly lower for all test cigarettes as opposed to the habitual brand reference cigarettes, these measures remained unaffected by taste or smoke yield of the test cigarettes * Harshness of smoke was higher in the dark tobacco category and generally decreased with the lower smoke yield cigarettes * Independent effects of taste and smoke yield were obtained for total puff volume, inhalation time and CO absorption, suggesting for a compensatory intensification of smoking behavior for low yield cigarettes and an independent increase of smoking intensity from mentholated to dark tobacco to blond tobacco	* Puffing patterns were analyzed using a puff flowmeter (puff volume, puff duration, and puff interval) * Respiration was continuously recorded on the minicomputer by means of the transthorax impedence method to get postpuff inspiratory latency, postpuff inspiratory time, and postpuff inspiratory amplitude * Mixed expiratory tidal CO air analyzed with a CO analyser * An infrared transducer was used to record signals of the vascular pulse wave for analysis of heart rate * Analog scales were used to assess subjective ratings of smoking satisfaction, need, and taste	ANOVAs, t-tests; polynomial regression analyses (BMDP)	* Measures of inhalation volumes dependent on subject position and were widely insensitive; usefulness of alveolar CO boost questionable
[redacted]	Nil, R., Buzzi, R., and Battig, K.	Pharmacology, Biochemistry, and Behavior (1986, volume 24, issue 3, p. 587-595)	117 regular smokers (69 male, 48 female)	One 90 minute session	To determine the effect of cigarette yields on topography measures, smoking behavior, and smoking absorption	* Pre- to postsmoking CO boost remained unrelated to the smoke deliveries of the cigarettes in both comparisons (interindividual and switching) * Estimated mouth intake of nicotine was strongly dependent on the smoke yield variables of the cigarette but remained uncorrelated with CO absorption * Discrepancies between mouth smoke intake and alveolar smoke absorption could not be explained by the volumes or durations of the postpuff respiratory cycle * Females had a lower blood pressure and smoked lighter cigarettes than men * There was an increases in puff volume with the lighter cigarettes * There was some compensation for differing nicotine yields, mainly among puffing variables * There were some sex differences in how cigarette yield affected smoking behavior	* A puff flowmeter with a pressure transducer and digital analyzer were used to determine puff volume, puff duration, puff interval, peak pressure, latency to peak pressure, and peak flow * Standard machine smoking data was used to estimate CO and nicotine mouth intake * A Co Analyzer was used to measure CO concentration in expiratory tidal air * Respiratory movements were recorded by the transthoracx impedance method * A dry spirometer was used to calibrate quantitatively the inspiratory and expiratory amplitudes of the thorax impendence signals to give postpuff inspiratory latency, postpuff inspiratory volume and duration * Blood pressure and pulse rate were measured with the module Elag Re 207-5 * A questionnaire on smoking behavior was given * WAS used to assess subjective need for smoking and smoking satisfaction	SPSS and BMDP software was used; cross-sectional correlations; comparisons of means by t-test method; multiple regression analysis	Subjects recognized low yield cigarettes immediately and rated them as less satisfactory

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The Mea... Int... M...	Reeves, N., and Dixon, M.	Report of the Joint Meeting of the Smoke and Technology Groups (1995, AVII)	18 regular consumers of 15 mg products, 21 of 9 mg products, and 40 of 6 mg products	One session smoking two cigarettes with 20 minute breaks in between	To examine and compare the smoking behavior patterns of 3 groups of smokers whose "own brand" products were of different tar yield	* Puff volumes, pressures, and durations were similar for all 3 groups of smokers * Puff numbers were marginally higher in the 6 mg group than in the other two * All 3 group exhibited a similar downward tend on puff volume and duration with increasing puff number * There were no marked differences in the behavior patterns of smokers of products differing in their tar and nicotine deliveries * The tobacco rod acts as a filter for smoke particulates and the progressive puff-by-puff increase in FDPM and nicotine delivery occurs primarily as a result of reduction in rod filtration as the rod shortens	* Flow rate through cigarette and pressure applied to cigarette during puff process measured by attaching cigarette to a holder incorporating an orifice plate and with two pressure points, all connected to a computerized program	Means given	Smokers unfamiliar with a product of lower delivery may smoke in a more intense manner for other sensory reasons
	Russell, M.A.H.	Progress in Brain Research (1989, volume 79, p. 289-302)			To describe advances in the literature on the physiological and psychosocial effects of nicotine on individual smoking behavior	* Nicotine's role in as the primary and controlling factor in smoking has now been firmly established by evidance from three main areas of behavioral research: role as primary reinforcer, its controlling influence in the self-regulation of smoke intake, and its effects on the cigarette withdrawal syndrome * Smokers downregulate their nicotine intake with great precision to avoid the toxic aversive effects of exceeding their usual blood nicotine levels, but up-regulation to maintain usual smoking levels is far less precise * Chronic exposure to nicotine induces an increase in the number of nicotinic cholinergic receptors in many parts of the brain, indicating the presence of structural as well as functional changes in the brain and nervous system of smokers * Sensory adaptation and tolerance to aversive effects develops rapidly * "Stimulation," "sedative," "addictive," and "automatic" motivation factors all correlate most highly with cigarette consumption	* Three-stage model of dependence: psychosocial motives; smoking for pleasurable, calming, and mildly stimulant effects of nicotine and habit; and need to stave off withdrawal * Nicotine intake from a cigarette depends on the intensity of puffing and the depth of inhalation * In view of the 2-h elimination half-life, significant cumulative build-up of nicotine levels occurs even at a modest frequency of smoking * It is pharmokinetically impossible to exceed a certain blood nicotine level * There is chronic partial blockade of the agonist effects of nicotine at postsynaptic cholinergic receptors * Due to the development of acute tolerance, smokers experience little positive impact from individual cigarettes under steady-state condition but do once deprived * The subjective and behavioral effects of nicotine in humans differ markedly, not only between individuals but also within individuals, according to the stage of their smoking career, their level of dependence and the time since their last few doses		

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	Sutton, S.R., et al.	British Medical Journal (1982, volume 285, p. 600-603)	55 smokers	One time (during afternoon or evening)	To examine the relationship between cigarette yields, puffing patterns, and blood nicotine and COHb concentrations in a sample of smokers smoking their usual brand of cigarette	* Total volume of smoke puffed from a cigarette was a more important determinant of peak blood nicotine cocnentration than the nicotine or tar yield of the cigarette, its length, or the reported nubmer of cigarettes smoked on the test day * When nicotine yield was controlled for, smokers of lower tar cigarettes not only puffed more smoke from their cigarettes than smokers of higher-tar cigarettes but they also had higher plasma nicotine concentrations, suggesting that they were compesnating for the reduced delivery of tar by puffing and inhaling a greater volume of smoke * The results based on carboxyhemoglobin concentrations were consistent with this interpretation * CO yield was the onyl variable to have a signficiant effect on carboxyhemoglobin levels * Subjects who had not smoked for more than half an hour tended to puff more intensely * Older people puffed less than younger people and women puffed more than men	* Subjects kept a record of their cigarette consumption that day up until the time of arrival and collected a sample of their butts * A puff analyser was used to measure number of puffs taken, the volume, pressure and duration of each puff, the itnerpuff intervals, and the time taken to smoke the cigarette * Blood samples were analyzed for COHb using an IL-182 Co-oximeter * Plasma nicotine concentrations were measured using gas chromatography	Regression Analysis	
	Weinhold, L.L., and Stitzer, M.L.	Pharmacology, Biochemistry, and Behavior (1989, volume 33, number 4. p. 853-858)	6 smokers (mean age of 36.3)	27 smoking trials for first experiment, 9 trials for second experiment (3 trials per day)	To further clarify how smoking behaviors (puff number and puff spacing) can influence biological exposure to CO from commercial brand cigarettes	* CO exposure (pre- to postsmoking increments) was directly related to the number f puffs taken for all cigarette yields * CO exposure from the high- and low-yield cigarettes was equivalent when the number of puffs taken from the low-yield cigarettes was increased by 50% * In contrast, CO exposure from ultralow-yield cigarettes was still marginally lower than exposure from high-yield cigarettes after a 4-fold increase in puff number * Puff spacing did not affect biological exposure to CO * The number of puffs taken during smoking can clearly affect biological exposure to CO, but compensation for lowered yield using increased puffs is much more difficult when ultralow- as compared with low or "light"-yield cigarettes are smoked	* Puff-respiratory cycles were recorded in real time * Puff number, interpuff interval, puff volume, inhalation duration, inhalation volume, and lung exposure duration were measured with flowmeter and Respitrace outputs * Expired end-air CO samples analyzed for CO content using an Ecolyzer 2000 * Vital capacity determined using a water spirometer	ANOVAs, Tukey's post-hoc tests	It is possible that puff flow rates may influence exposure and that nicotine levels might show effects that are not seen with CO analysis alone; respiratory system may not be able to absorb all the CO available from smoke of high-yield cigarettes during brief lung exposure times characteristic of cigarette smoking; filter-vent blocking plays a role in compensation

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